ANALYTICAL DEVICE

TECHNICAL FIELD

This invention relates to an analytical device, especially a sensor for detecting and measuring quantities of materials in fluid form.

Known sensors based on a compressible polymer element containing conductive filler and depending on 'percolation', that is, electrical contact between filler particles, are subject to various limitations, especially limited range of variation of electrical conductance.

PCT application PCT/GB00/02402 published as WO 00/79546 discloses a sensor for chemical species or biological species or radiation comprising:

a) a contacting head presenting a polymer composition comprising at least one substantially non-conductive polymer and at least one electrically conductive filler and being electrically insulating when quiescent but conductive when subjected to mechanical stress or electrostatic charge;
b) means for access of a test specimen to the head;
c) means to connect the head into an electrical circuit effective to measure an electrical property of the polymer composition.

The expression 'polymer composition' will be used herein to mean one containing polymer and conductive filler particles of metal, alloy or reduced metal oxide, and having a first level of electrical conductance when quiescent and being convertible to a second level of conductance by change of stress applied by stretching or compression or electric field. More details of compositions of this type are available in PCT applications GB98/00206 and GB99/00205, published respectively as WO 98/33193 and 99/38173, the disclosures of which are incorporated herein by reference.

We have now found advantageous sensors in which the properties of the polymer composition can be put to practical effect. In general, the preferred or optional features set out in PCT/GB00/002402 can be used in conjunction with the sensors according to the invention, in particular:

in the polymer composition the encapsulant polymer phase is highly negative on the triboelectric series, does not readily store electrons on its surface and is permeable to a range of gases and other mobile molecules into the head and/or onto its surface, thus changing the electrical property of the polymer composition.;

the contacting head may include stressing means, for example mechanical compressing or stretching or bending or a source of electric or magnetic field, to bring the polymer composition to the level of conductance appropriate to the required sensitivity of the sensor;

the sensor may afford static or dynamic contacting. For static contacting it may be a portable unit usable by dipping the head into the specimen in a container. For dynamic conducting, it may be supported in a flowing current of specimen or may include its own feed and/or discharge channels and possibly pump means for feeding and or withdrawing specimen. Such pump means is suitably peristaltic as, for example in medical testing;

the properties of the system may change in real time, for example in controlling an engine or chemical process or atmospheric quality;

in a preferred sensor the polymer composition may be excited by a linear or non-linear AC field. A range of techniques may be used to distinguish the signal of interest from noise and from interfering signals, for example—

reactance, inductance, signal profile, phase profile, frequency, spatial and temporal coherence;

in another example the polymer composition is held in a transient state by application of an electrostatic charge; then increased ionisation as a consequence of exposure to nuclear radiation changes the electrical resistivity, reactance, impedance or other electrical property of the system;

in a further example a complexing ionophore or other lock and key or adsorbing material is incorporated within the polymer composition. Such materials include crown ethers, zeolites, solid and liquid ion exchangers, biological antibodies and their analogues or other analogous materials. When excited by a DC, linear AC or non-linear AC field, such materials change their electrical property in accordance with the adsorption of materials or contact with sources of radiation. Such materials offer the potential to narrow the bandwidth for adsorbed species and selectivity of the system. In a yet further example an electride, that is a material in which the electron is the sole anion, a typical example of which might be caesium-15-crown-5 prepared by vaporising caesium metal over 15-crown-5, is incorporated within the polymer composition. Other ionophore, zeolite and ion exchange materials might be similarly employed. Such a composition has a low electron work function, typically <<1 electron-volt, such that low DC or non-uniform AC voltages switch it from insulative to conductive phase with decreasing time constant and increasing the bandwidth for adsorbed species and of the system. Such materials may be used to detect the presence of adsorbed materials and or radiation sources.

SUMMARY OF THE INVENTION

According to the present invention there is provided a sensor for chemical species or biological species or radiation presenting to a test fluid a polymer composition comprising polymer and conductive filler particles of metal, alloy or reduced metal oxide and having a first level of electrical conductance when quiescent and being convertible to a second level of conductance by change of stress applied by stretching or compression or electric field, in which the polymer composition is characterised by at least one of the features:

(a) in the form of particles at least 90% w/w held on a 100 mesh sieve; and/or
(b) comprising a permeable body extending across a channel of fluid flow and/or affording in-and-out diffusion of test fluid and/or
(c) mechanically coupled to a workpiece of polymer swellable by a constituent of test fluid.

In aspect (a) preferably the particles are at least 90% held on a 50 mesh sieve. For most purposes they pass an 18, possibly a larger e g 10, mesh sieve. They appear to be approximately spherical, of average diameter over 150, especially over 300, microns, and usually up to 1, possibly 2, mm. They may be used with advantage in embodiments of the invention in aspects (b) and (c). Preferred forms of the particles are described below.

The particles may be random-packed in a containing vessel without or with mutual adhesion, or supported on a yieldable framework such as foam or textile.

In aspects (a) and (b) the response of the sensor is due to the effect of the species or radiation on the polymer of the polymer composition or of a supporting framework. Preferably this effect is swelling of the polymer widening the separation between the conductive filler particles and thus a decrease in electrical conductance. Such widening lengthens